MONITORING FOR THE EFFECTS OF CLIMATE CHANGE ON THE FLORA VALUES OF THE TASMANIAN WILDERNESS WORLD HERITAGE AREA

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(with one text-figure, one plate and one table)

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Climate change is predicted to have significant impacts on Australia's biodiversity including the flora values of the Tasmanian Wilderness World Heritage Area (TWWHA). The current nature and direction of climate change impacts on biodiversity are uncertain. It is therefore prudent to establish a flora monitoring framework that captures a range of aspects of the vegetation values within the TWWHA. Monitoring will assist researchers and land managers in identifying values at high risk from climate change and allow for mitigating measures to be implemented. We outline criteria for a monitoring framework and recommend 14 sites be adopted as key flora monitoring locations within western and southwestern Tasmania. The sites that have been chosen – many of which have been the focus of previous research – provide a broad coverage of TWWHA environments allowing the opportunity for existing data to be used as a baseline to measure change.
Key Words: climate change, Tasmanian Wilderness World Heritage Area, flora, monitoring.

INTRODUCTION

Climate change is recognised as potentially having a range of highly significant impacts on Australia's biodiversity (Steffen *et al.* 2009) as well as a range of social and economic impacts. Increased atmospheric greenhouse gases, higher temperatures, changed rainfall and hydrological patterns with concomitant altered water quality and quantity, altered fire regimes (higher intensity and frequency of wildfire) and increased risks from pests, weeds and diseases are among the predicted impacts for Tasmania. Climate change has become one of the key issues addressed by governments, with the Australian government now listing "loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases" as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 (DEWHA 2009). This listing highlights the need to establish a monitoring framework that assists in detecting and mitigating climate change threats to the environment and, particularly, to biodiversity.

The Tasmanian Wilderness World Heritage Area (TWWHA) has been recognised as an area of outstanding universal value for both its natural and cultural heritage (UNESCO 2008). The flora values of the TWWHA are particularly important to its inscription on the World Heritage list (Balmer *et al.* 2004), with many of these unique values facing existing threats from factors such as fire, pests, weeds and diseases. All these threats are likely to be exacerbated by the consequences of climate change (Resource Management and Conservation Division 2010).

In Tasmania the predictions for climate change are still uncertain at the regional level, particularly with regard to the nature, direction and intensity of effects. Tasmania is not sufficiently represented in the current global climate models which are of very coarse resolution. Consequently, the Climate Futures for Tasmania project (ACE CRC 2009) is developing finer-scale models that operate on a 10–15 km grid and provide more detailed predictions for the state. These models predict that the greatest changes will occur in the northeast and central northern Tasmania (ACE CRC 2009) and these changes are likely to include more extreme high temperatures and fewer frosts, changes in rainfall, increased incidence of high fire danger periods, increased storm surges and altered patterns of wind activity (PMSIEC Independent Working Group 2007). The climate change predictions for within the TWWHA are problematic, as reliable climate data are only available from a small number of sites, most of which are lowland coastal and none of which occur within the TWWHA itself.

The impacts that predicted climatic changes are likely to have on biodiversity are varied. At the genetic level there may be shifts in gene frequencies within populations of species, as well as changes in the patterns of clinal variation, hybridisation and speciation. At the species level, individual species are likely to have altered distributions, and to experience changes in lifecycle, phenology, habitat use, physiology and extinction rates, and in their interactions with other species. Changes in ecosystem and community structure and composition as well as changes in detrimental attributes such as number and abundance of invasive species are predicted.

Internationally, a number of programs has been established to monitor the effects of climate change on biodiversity, and in particular alpine and high-latitude environments. The International Tundra Experiment (ITEX) is a scientific network of experiments that examines the effects of increased temperature on selected plant species in tundra and alpine vegetation (ITEX 2009). The ITEX network pools data to examine the vegetation response at varying levels. The Global Observation Research Initiative in Alpine Environments (GLORIA) aims to establish and maintain a worldwide long-term observation network in alpine environments. It involves a single method which is replicated at an international scale (GLORIA 2009). Within Australia there is currently one GLORIA site established, at Kosciuszko National Park in New South Wales. Long-Term Ecological Research (LTER) sites provide information on ecological processes over long temporal and broad spatial scales (LTER 2009). In southern Tasmania there is one LTER site established, the Warra Long-Term Ecological Research Site, which facilitates the understanding of the ecological processes of Tasmania's wet forests (Brown *et al.* 2001, Warra 2009).

Given the uncertainties of spatial and temporal impacts of climate change, it is prudent to establish a broad scale program of monitoring of the key values within the TWWHA. Monitoring should allow for the detection of magnitude and direction of change as well as providing for the gathering of more proximal climate data through the use of portable weather stations and data loggers. A framework for vegetation monitoring within the TWWHA should be multi-disciplinary, building upon existing monitoring work and also be placed within a statewide context. Our paper aims to facilitate this by outlining current thinking about the scope, direction and priorities for a climate change monitoring program in the TWWHA. Further priorities will be developed in response to immediate needs and feedback from the broader scientific community. It is envisaged that the program will form the basis for further research projects on climate change within the TWWHA.

DESIGNING A MONITORING FRAMEWORK

A framework for monitoring should be transparent, repeatable and adaptable to changing circumstances. It must consider the setting of priorities, analysis of risks and the feasibility of implementing the program and achieving outcomes, and be conducted at appropriate temporal and spatial scales. Monitoring priorities are a function of the importance of the value, a risk analysis of the value which considers its susceptibility to purported threats, an analysis of the existing threats and their likely exacerbation under climate change scenarios, and the feasibility of achieving management outcomes. The logistics, cost-effectiveness and relevance of existing baseline data of any program must also be taken into account as well as ensuring that any monitoring program is established in such a way that it is statistically valid.

What to monitor

Since it is not feasible to monitor every aspect of vegetation within the TWWHA, a monitoring framework should focus on values that have been identified as either potentially sensitive to climate change or of importance for other reasons. Many of these values have been identified in Balmer *et al.* (2004). Similarly, the large number of flora species and communities that occur within the TWWHA (Balmer *et al.* 2004) makes it impractical to monitor all of them. Therefore, it is recommended that a surrogate approach to monitoring be adopted which can be combined with a selective program that targets key value components. Furthermore, any such monitoring program should aim to include some components of each level of biodiversity, i.e., components of genes, species, communities and ecosystem processes, as well as existing threats such as wildfires, droughts, pests, weeds and diseases.

Threats such as pests, weeds and diseases already pose a serious problem to vegetation in Tasmania, and are likely to be exacerbated by climate change. Some of these threats occur within the TWWHA and are already catered for by existing monitoring and management programs but others need to be addressed. Two examples of detrimental diseases currently found within the TWWHA and which have the potential to become more prevalent with climate change are the root-rot pathogen, *Phytophthora cinnamomi* Rands (Podger & Brown 1989, Podger *et al.* 1990, Rudman *et al.* 2005), and myrtle wilt, which is caused by the fungus *Chalara australis* Kile & Walker, and kills the dominant myrtle trees, *Nothofagus cunninghamii* (Hook.) Oerst., in rainforest (Packham 1991, Packham *et al.* 2008). *P. cinnamomi*, in particular, is predicted to increase its geographical range and the range of communities in which it can become active, with a warmer, drier climate. Other threats such as observed dieback in conifers and eucalypts on the Central Plateau (Whinam *et al.* 2001, Calder & Kirkpatrick 2008) are also likely to be exacerbated and require particular monitoring attention. Weeds are a concern as a change in climate could allow some weedy species with particular attributes the opportunity to expand their range. Issues with weeds and other pests and diseases not currently recognised as high threats but which may become threatening under climate change are likely.

In addition to monitoring flora, any monitoring program within the TWWHA should be capable of providing useful ancillary climate and weather data, through the use of portable weather stations and data loggers. These data could be useful for providing information on fine-scale patterns at a local scale and as a means of calibrating data from existing Bureau of Meteorology stations. The collection of fire data and the identification of key refugia under different climate change scenarios, although not monitoring tools in themselves, would be a vital component of any long-term monitoring plan.

How to monitor

There are many different forms of monitoring and many tools available to assist the process. While some are proven and have been in use for years, others are still in development. For any monitoring program it is necessary to consider emerging technologies while not ignoring existing techniques that have proved reliable and cost-effective. A recommended system of monitoring is to use relatively cheap tools as far as possible for routine and broad scale monitoring, whilst intensive and more expensive techniques should be used for detailed monitoring of aspects that have been identified as critical and strategically significant.

A summary of the main methods available for monitoring is presented in table 1, with some comment about their relative usefulness and cost-effectiveness for different purposes.

Whilst not strictly a form of monitoring, past studies and studies of the past can provide useful contextual and baseline data, which can help determine whether current and future events are within or fall outside of the normal range of variability seen in nature. A monitoring technique currently being employed as one assessment of change in the alpine and subalpine regions of the TWWHA is the use of ground-based photo points, as demonstrated in plate 1 in which the original photos were taken in 1985 and the later series in 2009. The photos graphically demonstrate both the change in cover and the increase in woodiness of the vegetation over the intervening 24 years.

There are many good historical photographs taken from known vantage points in the TWWHA which would be useful for photo point monitoring of vegetation. Existing photo points established for other purposes may also prove useful, e.g., photo points established for track and campsite monitoring by Dixon *et al.* (2004).

TABLE 1
Summary of different monitoring tools and their applicability

Method	Use	Relative cost (high, moderate, low)	Comments
Satellite imagery	Remote sensing	Low-moderate depending on satellite and resolution	Can be used for broad scale vegetation monitoring, detecting change over time
Aerial photography	Detection of change at finer scale than satellite imagery	Low	Provides coverage of entire TWWHA with records back to 1940s
Still or video cameras linked to GPS	Monitor change over time	Low	Applications have included mapping of fire boundaries in planes with GPS and mapping distribution of *Nothofagus gunnii*
LIDAR	Detection of vegetation heights and topography from the air	High	Highly accurate measure of topography and vegetation cover
Ground-based photo points	Detect change over time	Low	Useful tool for looking back in time and extending the range of data applicable to climate change
On-ground plot and transect studies	Provide detailed information of species presence and community structure	High (involves a large number of people hours)	Useful tool for calibrating of other techniques such as aerial photograph interpretation
Modelling	Assists in understanding the results of monitoring	Low	Provide a link between research questions, monitoring results and applied management

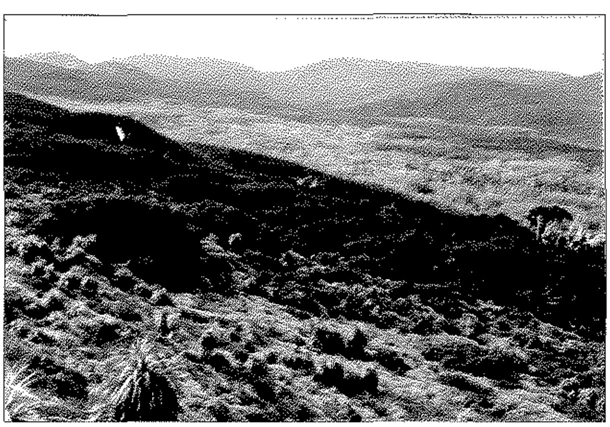

PLATE 1
An example of the use of long-term photo points in the Snowy Range, Tasmania, for assessing changes in vegetation over time. The top photo was taken by J. Balmer in 1985, with the subsequent photo taken by J. Styger in 2009.

When to monitor

Timing is an important component of a strategic monitoring program. Knowledge about current levels of change, altered rates of change, the occurrence of thresholds and stepped changes may all influence current and future priorities for monitoring and management. If monitoring is too infrequent, important signals may be missed, but it is not cost-effective to monitor too frequently or to monitor everything at the same frequency. Therefore, a balance has to be reached, and this will depend in large part on expert opinion about the likelihood and timing of observable change and on the perceived priority of the particular aspect to be monitored compared with other components and places. Thus, timing of monitoring is a key aspect of a program but needs to be built explicitly into the overall protocol at the program level.

Where to monitor

Deciding where to monitor depends on the nature of the object(s) to be monitored and their spatial scale of occurrence, thus monitoring should be done at multiple scales. In order to strategically inform the layout of monitoring sites within the TWWHA it is desirable that an Environmental Domain Analysis (EDA) be prepared to provide an objective basis for placement, to ensure that the range of environments within the TWWHA is captured. An alternative strategy would be to use a geographically stratified sample of the range of vegetation types, but an EDA is recommended because it has been demonstrated that broad vegetation classes are not necessarily ideal surrogates for other components of biodiversity (e.g., Richardson 1990, Mesibov 1998, Pharo *et al.* 2000).

In the absence of an EDA we have suggested a number of key sites that aim to provide the proximal needs for targeted monitoring, but also to provide a framework for a comprehensive coverage of the TWWHA that capitalises on existing infrastructure. Figure 1 shows recommended monitoring sites within and adjacent to the TWWHA. The sites target most of the existing monitoring sites plus some areas suggested to fill gaps in existing programs. The suggested sites were chosen after consideration of their accessibility, past monitoring history and ability to cater for multi-disciplinary monitoring programs.

Cradle Valley

Cradle Valley has been a site of monitoring since at least the 1970s. Vegetation within the valley includes moorland and *Sphagnum* L. communities, alpine, subalpine and rainforest communities as well as numerous species of alpine conifers. In addition to vegetation studies (e.g., Sutton 1928, Kirkpatrick & Balmer 1991), research has focused on the bryophytes and lichens of the area (Jarman 1988, Kantvilas 1988), erosion studies (Calais & Kirkpatrick 1986, Wild 2008), climate studies and fauna monitoring (Jones 2000, Jones & Barmuta 2000). The area is one of the key visitor sites of the TWWHA and accordingly there is a long-established photographic record for the area.

Pelion Plains

Pelion Plains is one of two locations that were a focus of a Wilderness Ecosystems Baseline Study (WEBS) in 1989–90, consequently there is considerable information about the flora of the area albeit without relocatable plots. Being in the middle of the popular Overland Track there is also a long-established photographic record for the area.

Eastern Central Plateau

The Eastern Central Plateau is a large area in which many studies have occurred in disparate locations. Some study sites are easily accessible while others are located some distance from main roads. As the Eastern Central Plateau is predicted to be the area within the TWWHA to be first and most

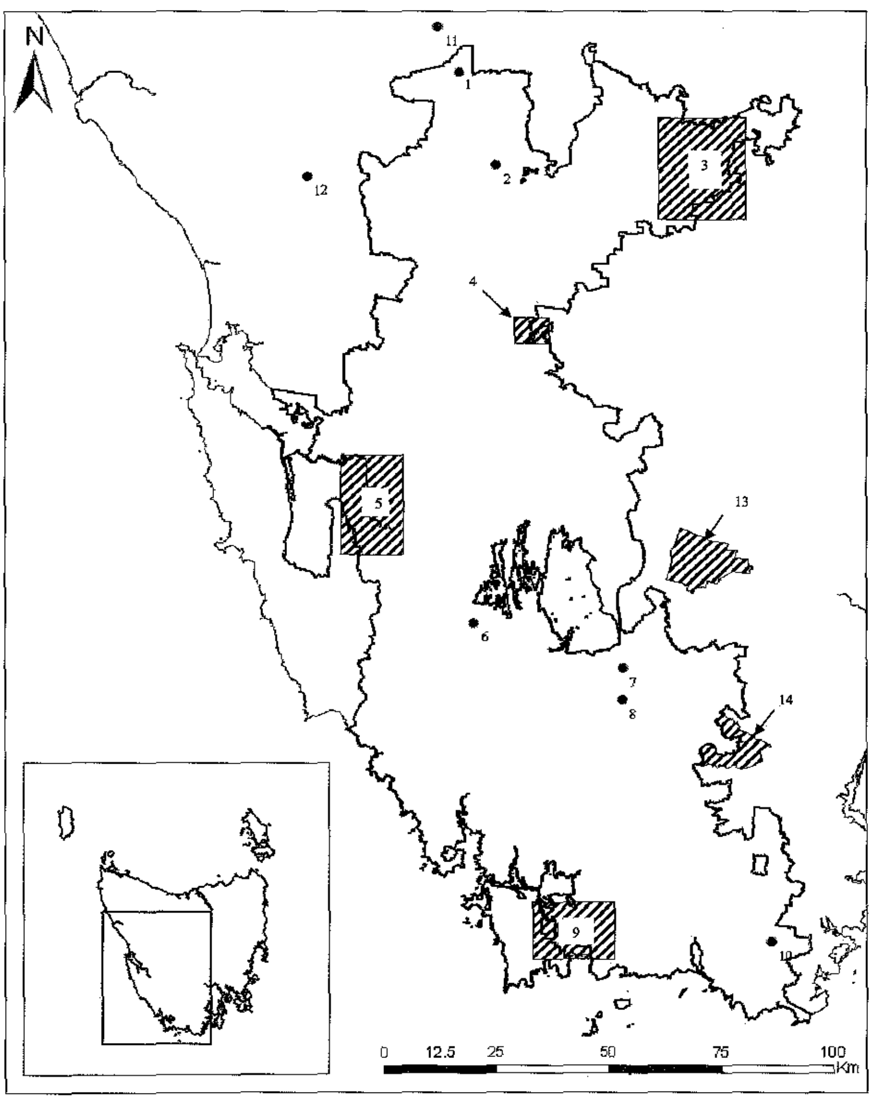

FIG. 1 — Map of recommended sites that could form the focus for long-term monitoring programs of flora and vegetation within the Tasmanian Wilderness World Heritage Area. 1, Cradle Valley; 2, Pelion Plains; 3, Eastern Central Plateau; 4, Mt Rufus-Navarre/King William Plains; 5, Lower Gordon/Olga Rivers; 6, Mt Sprent; 7, Gelignite Creek; 8, Condominium Creek; 9, Melaleuca and environs; 10, Hill One – Moonlight Ridge; 11, Vale of Belvoir; 12, Mt Read/Mt Hamilton; 13, Mt Field National Park; 14, Warra Long Term Ecological Research Site.

significantly affected by climate change (Calder & Kirkpatrick 2008) it is recommended as an important monitoring site. The vegetation of the Eastern Central Plateau includes alpine, subalpine, *Sphagnum* and conifer communities. Numerous studies have occurred on the Eastern Central Plateau, with permanent vegetation plots dating from 1973 (Bridle *et al.* 2001). Other research has included studies into recreational impacts (e.g., Whinam *et al.* 1994, Whinam & Chilcott 1999), fire, hydrology, *Sphagnum* harvesting (Whinam & Buxton 1997), vegetation genetics (e.g., Potts *et al.* 2001) and conifer dieback (Whinam *et al.* 2001).

Mount Rufus – Navarre Plains/King William Plains

The area around Navarre and King William Plains has been a centre for extensive study in the past few years. Studies have focused on fire, vegetation and animal relations within buttongrass moorland (e.g., Storey *et al.* 2001, Driessen & Greenslade 2004, Green 2007) as well as the establishment of an altitudinal transect through the treeline on the nearby Mount Rufus (ES Link 2006). Snow depths on Mount Rufus are taken irregularly by the Parks and Wildlife staff at Lake St Clair and regular records exist for the period 1986–94.

Lower Gordon/Olga rivers

The Lower Gordon River and surrounds have been the focus of a number of ongoing monitoring programs. In 1975–78 a comprehensive set of studies was carried out on the biophysical attributes of proposed impoundment areas. Information was collected along 14 accurately surveyed transects having a total length of c. 30 km, covering geology, soils and geomorphology, fire history, vascular plants, lichens, vertebrates and invertebrates (Jarman & Crowden 1978). Although not easily accessible, this area is recommended as a monitoring site due to the extensive baseline data that have already been collected.

Other monitoring projects to have occurred in the area include the Basslink monitoring program (e.g., Davidson & Gibbon 2001) and the Lower Gordon River bank erosion monitoring program (Bradbury *et al.* 1995), which includes the use of long-term photo points.

Mount Sprent

Mount Sprent is located in the central TWWHA and has considerable potential to become a monitoring site because of its strategic location, relatively good access and the abundance of past studies conducted there. Past studies have provided information about climatic variables (Kirkpatrick *et al.* 1996), soils (Bridle & Kirkpatrick 1997), vascular plants (Kirkpatrick *et al.* 1996, Bridle & Kirkpatrick 1997), non-vascular plants (Jarman 1987, Kantvilas 1987) and vegetation across a range of altitudes (Kirkpatrick *et al.* 1996). The vegetation consists of alpine and moorland communities, with rainforest and scrub communities occurring on the lower slopes.

Mount Sprent could also serve as a surrogate for altitudinal monitoring within the TWWHA that utilises baseline data collected over 20 years ago. In 1986 Kirkpatrick & Brown (1987) surveyed the altitudinal variation on four remote southwestern mountains. Given the advantage of it relatively easy access it is feasible that Mount Sprent could be used to represent the observed variation occurring on mountain tops and could be coupled to the data collected in this earlier study. However, a renewed monitoring program of the original four mountains along with Mount Sprent would have to initially occur to calibrate Mount Sprent as a surrogate.

Gelignite Creek/Condominium Creek

Gelignite Creek has been the location of a number of studies examining moorland ecology. Vegetation studies examining moorland copse boundaries occurred in 1990 (Marsden-Smedley 1990) with a repeat study occurring in 2000 (Storey *et al.* 2001). However, although the methodology remained similar, the original transects were not able to be precisely relocated. More recently a study into peatland hydrology has occurred within the Gelignite Creek catchment with a control site being established at Condominium Creek (K. Storey pers. comm.). Gelignite Creek was prescribe-burned in May 2009 and vegetation, soil, geomorphology and hydrology data have been collected. The two catchments are recommended as monitoring sites as they are easily accessible and already fulfil desirable criteria for multi-disciplinary studies.

Melaleuca and environs

The Melaleuca Plains and surrounding areas have a long history of botanical and zoological studies with the area being a focus for one of the WEBS programs. The vegetation of the area is largely moorland, with scrub occurring on higher, better drained areas, and coastal communities occurring around the bays. Past studies of the area include vegetation studies for fire research, and as part of the Orange-bellied Parrot, *Neophema chrysogaster* (Latham, 1790), recovery program (Brown & Wilson 1984), botanical studies (e.g., Lynch & Balmer 2004), studies of *Phytophthora cinnamomi* damage using fixed and relocatable plots (e.g., Brown & Podger 1982, Brown *et al.* 2002) and studies of the peats and peat mound formation (di Folco 2007). Extensive and ongoing studies into the coastal processes have been conducted by Rudman *et al.* (2008) while Edgar *et al.* (2007) have studied the marine environment of Port Davey–Bathurst Harbour. The area remains an important focus for recreational visits as well as habitation by the King family and accordingly has a potentially long record of useable photo points. This plethora of background information, relative accessibility of the area and its strategic location make it an important area for incorporation into a climate change monitoring program.

Hill One/Moonlight Ridge

A series of relocatable transects and plots were established along an altitudinal gradient at this site in 1989 (Lynch & Kirkpatrick 1995). Repeat sampling of the original vegetation plots occurred in 2000 (Kirkpatrick *et al.* 2002). The vegetation of Hill One consists of alpine and fjaeldmark communities. Information on the soils, geomorphology and climate of the area has also been collected and there are a series of relocatable photo points (Kirkpatrick *et al.* 2002).

Vale of Belvoir

The Vale of Belvoir is an area of alpine tussock grassland that is currently managed by the Tasmanian Land Conservancy. The Vale of Belvoir has been used extensively as a study area in the past; however, few of these studies have been published. Previous studies at the Vale of Belvoir include research into cattle-grazing effects (L. Gilfedder pers. comm.) and fire-grazing interactions (J. Kirkpatrick pers. comm.). The area also has significant geomorphological values, including karst. The Vale of Belvoir is recommended as a monitoring site as it is easily accessible and is a stunning example of Tasmanian alpine grassland.

Mount Read/Mount Hamilton

The areas around Lake Johnson on Mount Read and the nearby Mount Hamilton are key botanical sites for gathering an understanding of past climates and also for indicating likely future changes. The vegetation of the area includes alpine, rainforest and moorland communities. The fire history of the area has been reconstructed (M. Peterson pers. comm.) and significant dendrochronological and palynological work has been undertaken (e.g., Anker 1991, Buckley *et al.* 1997, Anker *et al.* 2001). Relocatable plots across fire boundaries were established in the early 1980s by Kirkpatrick & Dickinson (1984) and have been resurveyed in 1998 and 2010 (J. Kirkpatrick pers. comm.). The sites at Mount Read lie to the west of the northern part of the TWWHA and are thus ideally located to provide strategic coverage across the TWWHA.

Mount Field National Park

Mount Field provides an easily accessible study site, with a range of vegetation communities and a long history of past studies, and could prove significant for monitoring likely climate change effects that are relevant to similar environments within the TWWHA.

Mount Field National Park occupies an altitudinal range of 160–1400 m a.s.l. and hence provides a range of environments within a small area. Vegetation communities occurring within the national park include alpine, subalpine, forest and moorland communities as well as areas of conifer, deciduous beech (*Nothofagus gunnii* Hook.) and *Sphagnum*. Studies have examined the variation in vegetation with altitude (Ogden & Powell 1979, Barker 1993) and the repeat monitoring of cushion plant and snow patch communities (Gibson & Kirkpatrick 1985, 1992). Kirkpatrick & Dickinson (1984) established relocatable plots across fire boundaries in the early 1980s, and these plots have been resurveyed in 1998 and 2010 (J. Kirkpatrick pers. comm.). These studies provide a potential opportunity for re-surveying periodically to monitor and assess changes.

Warra LTER site

The Warra LTER site was established by Forestry Tasmania and the Parks and Wildlife Service in 1995 and lies within and adjacent to the TWWHA (Brown *et al.* 2001). Vegetation within Warra includes alpine, tall eucalypt forest, moorland and riparian communities. Research and monitoring work is multi-disciplinary and can assist understanding of climate change effects which have direct relevance to TWWHA concerns.

Ancillary information

Carbon storage

The TWWHA is an important repository of carbon at a national and international scale as many of the soils that underlie the TWWHA are organic. Tasmanian organic soils have been classified into 20 classes by di Folco (2007); these classes are based on four characteristics of the lower soil horizons, viz: carbon content, humification type, nitrogen content and horizon depth. It would be useful to calculate the fluxes of carbon from accretion in long unburnt areas to loss through soil respiration, fire and dissolution and stream transport, as well as the amount of run-off carbon that is sequestered offshore. A comprehensive program would involve establishment of a large research project with a strong monitoring component, and that is dependent on a multi-disciplinary approach, involving soil science, plant ecology, hydrology, fire ecology, remote sensing and modelling skills. The monitoring sites recommended above should encompass the full range of organic soil classes and vegetation types recognised by di Folco (2007) and so should provide a useful basis for ancillary monitoring of soil carbon storage and fluxes.

Climate change refugia

The identification of potential climate change refugia is a fundamental part of a strategy to manage for climate change in the TWWHA. Kirkpatrick & Fowler (1998) analysed the locations of likely glacial refugia in the mid-1990s. It is recommended that further analyses occur, incorporating more recent data and current climate change scenarios based on the Climate Futures models. A new analysis would provide information on where refugia are likely to be located under current climate change predictions and this will determine what monitoring needs are required if these sites are not already captured by an existing program.

Information collation

A precursor to a monitoring program is a system for data capture and storage of existing and future data from all relevant researchers and land managers along with a register of studies. The basic infrastructure for this is already in place within the Natural Values Atlas managed by the Tasmanian Department of Primary Industries, Parks, Water and Environment. Information capture would ideally include all past and present data together with tools such the electronic and hard copy aerial photograph compendium held by Information and Land Services and on the LIST.

Many relevant datasets are in active use as part of ongoing research programs. A procedure for accessing and curating the data when the program is completed from the perspective of the current data holder or on their retirement from active participation should be adopted. The data should be captured in raw format as far as possible so it can be manipulated in different ways as new techniques and methods become available and new questions need to be answered. Many sites may become a resource in the future when climate change effects become clearer and the data could be valuable for monitoring sites for before-after, control-impact (BACI) studies especially to assess the impacts of extreme events.

CONCLUSIONS

The vegetation of the TWWHA has been lauded at an international level for its aesthetic qualities and uniqueness. Our proposed framework for the monitoring of these flora values aims to determine changes that are occurring as a result of human-induced climate change. The criteria for the monitoring program in this framework include:

- A focus on values identified as potentially sensitive to climate change as well as being sufficiently broadly based to capture new issues as they arise.
- The monitoring program should capture components of each level of biodiversity, i.e., genes, species, communities and ecosystem processes as well as issues such as wildfires, droughts, pests, weeds and diseases.
- The program should incorporate sites where relevant baseline data already exists.
- The program should be statistically valid.
- The program should be capable of providing useful ancillary climate and weather data.

- The program should use relatively cheap tools for routine and broad scale monitoring, with intensive and more expensive techniques to be used when needed for detailed monitoring of aspects that have been identified as critical and strategically significant.

In addition to these criteria, it is recommended that a program be devised for calculating carbon fluxes within the peatlands of the TWWHA and that the identification of potential climate change refugia within the TWWHA should be undertaken. Data obtained from long-term monitoring sites within the TWWHA should be captured in the Tasmanian Government's Natural Values Atlas. Such a monitoring system could usefully be expanded to cover all Tasmanian vegetation and ecosystems more generally.

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